Unit 9

CP CHEMISTRY STUDY GUIDE

The Kinetic Theory of Matter (Chapters 10 and 14)

Unit Goals ("During this unit I will…")

1. Explain the behavior of matter in terms of the relationships between temperature, kinetic energy and intermolecular forces.
2. Describe how the Kinetic Molecular Theory of Matter can be used as a model to explain the states of matter (solid, liquid, gas) and their properties.
3. Quantify the transfer of heat between substances during phase changes using appropriate mathematical formulas and constants.

PA Academic Standards - Science & Technology

3.4.10/12.A. Explain and apply concepts about the structure and properties of matter.

- Describe phases of matter according to the Kinetic Molecular Theory.
- Explain how the forces that bind solids, liquids and gases affect their properties.
- Quantify the properties of matter (e.g., density, solubility coefficients) by applying mathematical formulas.

3.4.10/12.B. Apply and analyze energy sources and transfers of heat, conversions and their relationship to heat and temperature.

- Apply appropriate thermodynamic concepts (e.g., conservation, entropy) to solve problems relating to energy and heat.

Essential Skills ("Upon completion of this unit I should be able to…")

YES…I Can!

- ❑ Compare and contrast the terms intra- and intermolecular forces, and give examples of each. (14.1)
- ❑ Compare and contrast the properties of various states of matter including solids, liquids, and gases, using Kinetic Theory. (14.1, 14.6)
- ❑ Explain the relationship between a molecule's polarity, intermolecular forces, melting and boiling points. (14.1-14.2)
- ❑ Explain the differences between kinetic and potential energy as they relate to the composition of matter. (10.1)
- ❑ Compare and contrast the terms temperature, heat, endothermic, and exothermic. (10.2 – 10.3)
- ❑ Compare and contrast the various scales used to measure temperature. (5.7)
- ❑ Compare and contrast the terms: Heat of Fusion, Heat of Vaporization, and Specific Heat Capacity. (14.3, 10.5)
- ❑ Describe the various segments of a heating/cooling curve in terms of changes in: kinetic energy, temperature, and intermolecular forces. (14.2)
- ❑ Correctly and consistently calculate the energy changes involved in various segments of a heating/cooling curve using appropriate mathematical formulas. (14.2-14.3)
- ❑ Correctly complete any of the "blue" numbered problems on pp. 318-321 and 463-465.

Name: ____ Date: ________ Period: ________

Unit 9

The Kinetic Theory of Matter

(ChemActivity: Types of Energy and States of Matter)

3.4.10/12.A. Explain and apply concepts about the structure and properties of matter.

4 – Complete/Accurate   3 – One/Few errors   2 – Many errors   0 – Incomplete

1. **On your own…** Read sections 10.1-10.3 on pp. 289-293 and section 14.1 on pp. 441-444. You should also view the online tutorial "Intermolecular Forces" through the link on Mr. Campbell's webpage.

2. What is energy?

3. Compare/contrast kinetic and potential energy:

4. Compare and contrast the terms temperature and heat. Which is an *extensive* property? Why?

5. Explain why water is a liquid at room temperature (~25°C) when other substances of similar molar masses are gases:

6. Explain the difference between an *intermolecular force* and an *intramolecular force*:

7. Explain why hydrogen bonds are not true chemical bonds: (HINT: You may wish to review our definition of bonds from Unit 7/8)

8. What are *London Dispersion Forces*? How do these attractive forces compare to hydrogen bonds?

9. Explain why methane (CH_4) is a gas at 25°C, while hexane (C_6H_6) is a liquid, and wax ($C_{25}H_{52}$) is a solid:

10. Describe the relationship between the strength of intermolecular forces and a substances melting point:

11. Explain how an ionic compound like NaCl can dissolve in a polar substance like water…what role do intermolecular attractions play in this process:

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Unit 9

The Kinetic Theory of Matter

(ChemActivity: NOVA: *Absolute Zero*)

3.4.10/12.A. Explain and apply concepts about the structure and properties of matter.

4 – Complete/Accurate 3 – One/Few errors 2 – Many errors 0 – Incomplete

Directions: As you watch the video, NOVA: *Absolute Zero*, listen for information to answer the following questions. IF YOU ARE ABSENT…the video may be watched, in its entirety, on the NOVA website at: http://www.pbs.org/wgbh/nova/

1. What contributions to the study of “cold” were made by…

- Robert Boyle:

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- Guillaume Amontons:

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- Clarence Birdseye and Willis Carrier:

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2. Compare/contrast the Celsius and Fahrenheit temperature scales and describe the development of each:

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3. In terms of kinetic energy…what is absolute zero?

4. Describe the Kelvin Temperature scale:

5. How does quantum theory relate to the study of super cold temperatures? What contributions were made by Albert Einstein?

6. What are quantum computers?

7. How close to producing a temperature of absolute zero have scientists been able achieve? Is it possible to ever get to absolute zero?

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Unit 9

The Kinetic Theory of Matter

(ChemActivity: Phase Changes of Water)

3.4.10/12.A. Explain and apply concepts about the structure and properties of matter.

4 – Complete/Accurate | 3 – One/Few errors | 2 – Many errors | 0 – Incomplete

1. **On your own…** Read sections 14.2 and 14.3 on pp. 444-449, then view information on the following website:

   http://www.kentchemistry.com/links/Matter/HeatingCurve.htm

2. What is the relationship between temperature and the kinetic energy of particles of a substance?

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3. Describe what happens to the particles of a solid substance as you begin to add heat:

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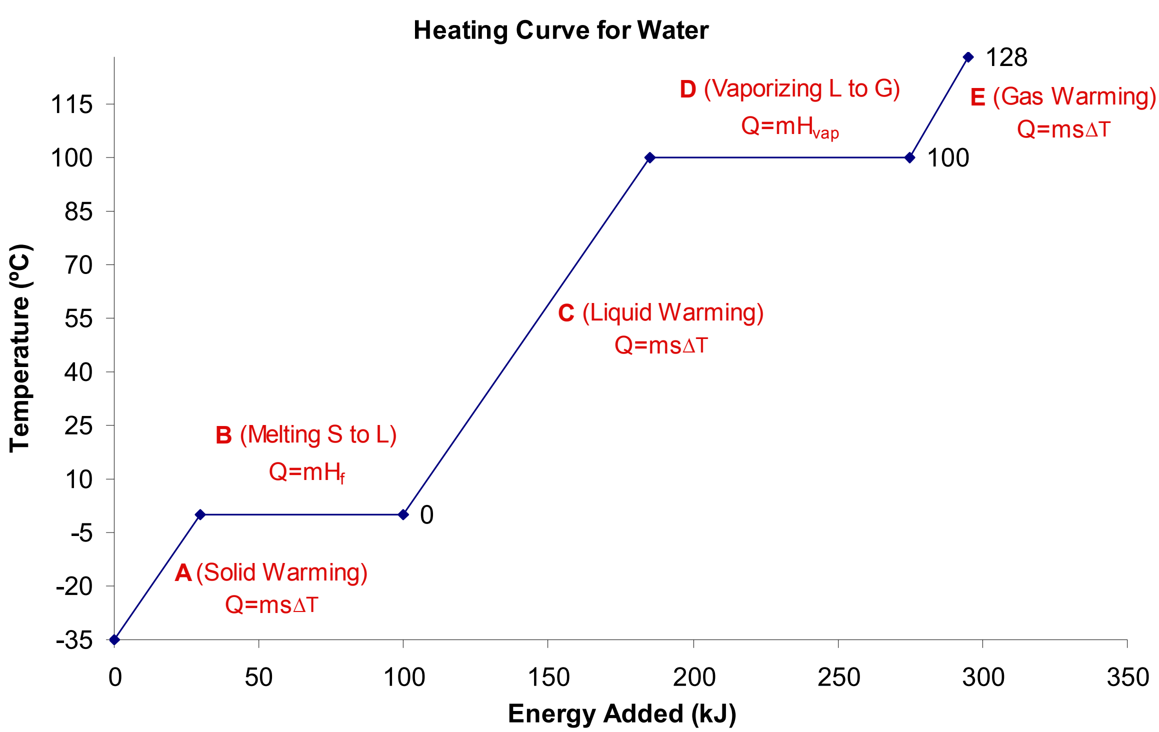
Use the heating/cooling curve pictured below to answer questions 4-5 on the back side of this sheet.



4. On what segment(s) on the graph is the kinetic energy of the water molecules increasing? How do you know this?

5. Explain why there are sections on the graph where the temperature is not changing, but energy is still being added. Where does this energy go?

6. What is meant by "heat of fusion" (H_f):

7. What is meant by "heat of vaporization" (H_{vap}):

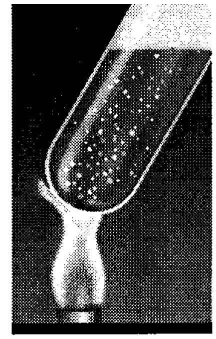
8. The heat of fusion value for water is 334 J/g, while the heat of vaporization value is 2260 J/g. What does this tell you about the relative amounts of energy required to cause water to change states?

9. How can the melting point and boiling point be determined by creating a heating/cooling curve for a substance?

10. Explain the difference between "melting" and "freezing":

Name

Date Class



CHEMLAB AND MINILAB WORKSHEETS

CHEMLAB 10

Molecules and Energy

As you break from a saunter to a full gallop to get to your next class, your kinetic energy changes. Your energy was increased by the muscles of your legs propelling you down the hallway. In terms of energy transfer, the muscles of your legs transferred energy obtained from the foods you have eaten. Can you observe changes in a substance as energy is transferred to it?

PROBLEM

How does energy transferred to or from a molecular substance affect the average kinetic energy of its molecules?

OBJECTIVES

- **Observe** the temperature changes and changes of state when a molecular substance is heated and cooled.
- **Make and use graphs** to analyze temperature changes.
- **Interpret** temperature changes in terms of the changes in the average kinetic energy of a substance's molecules.

MATERIALS

timer	beaker tongs
hot plate	test-tube holder
20-mm × 150-mm test tube	clamp and ring stand
400-mL beakers (2)	stearic acid
Celsius thermometers (2)	

SAFETY PRECAUTIONS

Use beaker tongs when handling the beaker of hot water and a test-tube holder when handling the hot test tube.

PROCEDURE

1. Use the data tables to record your observations. Label one *Heating* and the other *Cooling*.
2. Pour 300 mL of tap water into a 400-mL beaker and place the beaker on a hot plate.
3. Place a thermometer in the beaker of water. Turn on the heat and monitor the water temperature until it reaches 90°C. Maintain the water temperature at 90°C by using the heat control of the hot plate or by adding cold water.
4. Half fill the test tube with stearic acid. Gently push the bulb of the second thermometer down into the substance. After the temperature of the thermometer has adjusted to the stearic acid, record this temperature in the first line of the *Heating Data* table.
5. Attach the clamp to the test tube and immerse the tube in the beaker of hot water as shown. Read and record the temperature and the physical state or states of the stearic acid every 30 seconds until all of the material has melted and its temperature is about 80°C.
6. Pour 300 mL of cold tap water into the second 400-mL beaker.
7. Remove the test tube and contents from the first beaker and immerse it in the cold water in the second beaker. Read and record in the *Cooling Data* table the temperature and physical state or states of the stearic acid every 30 seconds until the material has solidified.

DATA AND OBSERVATIONS

Heading Data		
Elapsed Time (s)	**Temperature (°C)**	**Physical State**
0		
30		
60		
90		
120		
150		
180		
210		
240		
270		
300		
330		
360		
390		
420		
450		
480		
510		
540		
570		
600		

Cooling Data

Elapsed Time (s)	Temperature (°C)	Physical State
0		
30		
60		
90		
120		
150		
180		
210		
240		
270		
300		
330		

ANALYZE AND CONCLUDE

1. **Making Graphs** Graph the heating data by plotting temperature readings on the vertical axis and time on the horizontal axis. Connect the data points with straight lines or smooth curves. Label the appropriate segments of the graph *solid, solid and liquid,* or *liquid.* Graph the cooling data in the same way.

2. **Interpreting Data** Divide each graph into three intervals by drawing two vertical lines at the points where the slope of the graph changes. Label the intervals of the first graph *A, B,* and *C* and those of the second graph *D, E,* and *F*.

3. **Drawing Conclusions** According to your data, what is the approximate melting point of stearic acid?

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4. **Relating Concepts** Describe how the kinetic energy of the stearic acid molecules changed during each interval.

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APPLY AND ASSESS

1. Describe how the molecular motion changed during each segment of the heating and cooling curves.

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2. Suppose twice as much stearic acid were used. What would the graph look like? Make a sketch.

Name: ____ Date: __________ Period: _________

Unit 9

The Kinetic Theory of Matter

(ChemActivity: Heating Curve Practice Problems)

3.4.10/12.A. Explain and apply concepts about the structure and properties of matter.

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1. Draw a heating curve for ice at -35.0ºC being converted to steam at 150.ºC:

2. Label the following segment(s) on the graph above: Write the formula used:

Label the following segment(s) on the graph above:	Write the formula used:
Warming	Q=
Melting	Q=
Vaporizing	Q=

3. What are the following values for water (include units):

H_f=	S_{ice}=
H_{vap}=	S_{water}=
	S_{steam}=

4. How many <u>calories</u> are needed to convert 312.0g of ice at -35.0°C to liquid water at 25.0°C: (Hint: Use the graph above to determine the formula(s) needed)

5. How many joules are required to melt 275.0kg of ice (ASSUME: the ice starts at 0.0°C):

6. What mass of water (in kg) at 100.0°C could be completely vaporized with 2.70×10^3 cal of energy:

7. How many joules (J) of energy are released when 6.80×10^3g of steam at 100.0°C are completely frozen to ice at 0.0°C:

8. Convert the H_f value for water (80 cal/g) to units of J/mol: (HINT: You will need to use the molar mass of water)

9. How much energy (in J) is required to completely melt 205.0 mol of ice at 0.0°C:

Name: ____ Date: __________ Period: _________

Unit 9

The Kinetic Theory of Matter

(CHEMACTIVITY: Heating Curve Practice Problems II)

3.4.10/12.A. Explain and apply concepts about the structure and properties of matter.

4 – Complete/Accurate 3 – One/Few errors 2 – Many errors 0 – Incomplete

1. A 12 oz. can of soda weighs about 355 grams. How many joules are released when a can of soda is cooled from 25.0 ºC (room temperature) to 4.0 ºC (the temperature of a refrigerator)?

2. How many calories of energy are required to completely melt 100. grams of ice which starts at a temperature of -40ºC? (Hint: Draw a heating curve graph!)

3. How many joules are required to completely boil 350. grams of water? (Assume the water is all liquid at 100.ºC)

H_f = 334 J/g or 80 cal/g H_{vap} = 2260 J/g or 540 cal/g

S_{ice} = 2.03 J/gºC or 0.500 cal/gºC S_{water} = 4.184 J/gºC or 1.0 cal/gºC S_{steam} = 2.06 J/gºC or 0.500 cal/gºC

CHECK YOUR ANSWERS HERE!

4. How many Kilojoules are required to heat 4.04×10^4 g of ice from minus 25.0 ºC to 125 ºC?

5. How much energy would be released (in KJ) if 2.02×10^4g of steam cooled from 125ºC to ice at -25ºC (HINT: You may be able to answer this by using some info from #4!)

H_f = 334 J/g or 80 cal/g H_{vap} = 2260 J/g or 540 cal/g
S_{ice} = 2.03 J/gºC or 0.500 cal/gºC S_{water} = 4.184 J/gºC or 1.0 cal/gºC S_{steam} = 2.06 J/gºC or 0.500 cal/gºC
CHECK YOUR ANSWERS HERE!

Name: ____ Date: __________ Period: _________

Unit 9

The Kinetic Theory of Matter

(ChemActivity: Heat of Fusion/Vaporization Data Analysis)

3.4.10/12.A. Explain and apply concepts about the structure and properties of matter.

4 – Complete/Accurate 3 – One/Few errors 2 – Many errors 0 – Incomplete

Directions: Use the data provided in the table below to solve the following problems.

		Fusion		Vaporization	
Substance		**Melting Point (ºC)**	**Heat of Fusion (j/mol)**	**Boiling Point (ºC)**	**Heat of Vaporization (j/mol)**
O_2	Oxygen	-219	444	-183	6820
N_2	Nitrogen	-210	720	-196	5577
NH_3	Ammonia	-78	5653	-33	23351
He	Helium	-272	20	-269	83
H_2	Hydrogen	-259	558	-253	452
I_2	Iodine	114	15648	183	4347
H_2O	Water	0	6008	100	40656

1. Based on the data provided above, how would the heating curve for ammonia differ from the heating curve for water? How would it be similar?

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2. Calculate the energy required (in joules) to change 45.8g of solid nitrogen gas (N_2) at -210.ºC to liquid nitrogen at -210.ºC

3. Show by calculation which requires more energy…changing 500.g of helium from liquid to gas, or changing 100.g of nitrogen from solid to liquid: (Assume that both gases are at their boiling or melting points, respectively)

4. In what state of matter would oxygen exist at a temperature of -190.ºC?

5. Convert the molar heat of fusion value for ammonia to units of cal/g:

6. Of the seven substances listed in the data table, which one(s) would exist as liquids at a temperature of -207ºC?

7. Of the seven substances listed in the data table, which one(s) would exist as gases at a temperature of -137ºC?

UNIT 9: Kinetic Theory REVIEW QUESTIONS

1. How is heat different from temperature?

2. What are you measuring when you "take a temperature" of something?

3. What are the various scales used to measure temperature?

4. If a system absorbs heat energy, will its temperature change?

5. Why are some substances solids at room temperature, while others are liquids and gases?

6. Why do substances, including water, not change temperature when they melt/freeze, or vaporize/condense?

7. What are heat of fusion and heat of vaporization?

8. How can the amount of energy required to cause water to change states of matter be quantified? What mathematical formulas apply? What are the variables (and associated units) within these formulas?

9. Complete the following problems: (Answers in back of textbook)

    - 21, 22…p.464
    - 59, 61…p.465

10. Complete the following online reviews:

    - Textbook Chapter 14
    - Sciencegeek